

UNIVERSITY OF CALIFORNIA PUBLICATIONS

COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

PLUM POLLINATION

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BULLETIN No. 310

JULY, 1919

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY

1919

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PLUM POLLINATION

By A. H. HENDRICKSON

Pollination experiments with plums and prunes have been carried on by the Division of Pomology of the University of California for five years. The work was done chiefly at the University Farm at Davis and in the Santa Clara Valley. Later, several varieties were experimented upon at Vacaville. These experiments have yielded much definite information regarding the necessity for cross-pollinating the different varieties to insure a satisfactory set of fruit.

Only two species of plums are of much commercial importance in California—namely, the Japanese (*Prunus triflora*, Roxbg.) and the European (*Prunus domestica*, Linn.). The former consists entirely of shipping plums, the chief varieties being Climax, Wickson, Kelsey, Burbank, Santa Rosa, Beauty, and Abundance. Of the European varieties, Tragedy, Clyman, Grand Duke, and Pond are used extensively for shipping, and the French (Agen or Petite) Imperial, Sugar, and Robe de Sergeant are used principally for drying.

In certain sections of the state, extensive areas are devoted to the growing of plums and prunes, and often large plantings consist of but one or two varieties. The State Commission of Horticulture has compiled figures which show that in the Santa Clara Valley alone there are over 61,000 acres planted to prunes, and that this acreage is largely planted to one variety, the French, with a few scattered plantings of Imperial and Sugar. Yields of many varieties of plums and prunes have not always been satisfactory and growers suspected the trouble might be due to improper pollination. Many complaints of this kind have reached the University both by private communication and through the public press. Most of these complaints have come from the growers of shipping plums, many of which are uncertain bearers. Such varieties as Tragedy, Pond, Satsuma, Wickson and others have been frequently reported in the agricultural papers as erratic in productiveness.

With prunes, the lack of fruitfulness generally did not so definitely point to lack of proper pollination. While the Imperial, Robe de Sergeant, and Silver prunes have long been considered shy bearers, the French and the Sugar have continued to bear more or less satisfactorily when set out in large blocks of a single variety.

Many growers in the Santa Clara Valley have noticed an appreciable falling off in their crops, and have been anxious for information relative to the cause. Improper pollination, due to self-sterility, was believed to be at least one important factor causing this imperfect set. Another factor has already been shown to be responsible to a degree for this failure to set commercial crops. This factor is the lack of honey bees in the orchards at blooming time. Proper pollination has been shown to be dependent upon insect agencies to carry the pollen.¹ It is probable that other factors such as pruning, cultivation, fertilization and irrigation will be shown to influence the amount of fruit set.

OBJECTS OF THE INVESTIGATION

It was with these problems in view that the Division of Pomology in the spring of 1914 began an investigation of the pollination question concerning the leading varieties of plums and prunes in California. The experiments were designed to answer the following questions:

1. What varieties are self-sterile (requiring cross-pollination)?
2. What varieties are self-fertile (not requiring cross-pollination)?
3. What varieties, although not self-sterile, may be benefited by cross-pollination?
4. What are the best pollinators for the various self-sterile varieties?
5. What is the relation of weather conditions to the set of fruit, open to pollination by natural agencies?

One of the main objects was to find out if possible what varieties were able to set fruit through the influence of their own pollen. Among the stone fruits, the peach has long been considered self-fertile, but Waugh and others have shown that most of the native American plums and many of the European plums require cross-pollination. More recently Gardner has shown that most varieties of sweet cherries are self-sterile, and, furthermore, certain varieties were inter-sterile as well. Tufts of California has verified Gardner's results with sweet cherries and also found that the same facts apply to certain varieties of almonds. The question as to the ability of varieties of plums to set and mature crops through the medium of their own pollen is of utmost importance to the grower. Moreover, the problem of affinity between varieties must be considered in order to recommend the proper varieties for interplanting.

¹ Cal. Agr. Exp. Sta. Bulls. 274 and 291, The Common Honey Bee as an Agent in Prune Pollination (1916, 1918).

Considerable progress was made upon other problems such as the effect of crossing upon the size and color of fruit, blossoming periods, amount of pollen produced, arrangement of trees necessary for cross-pollinating purposes, and other problems closely allied with the foregoing. In some cases definite information was obtained, while in others only general statements as a result of long continued observation can be made.

OUTLINE OF EXPERIMENTS

Location.—Most of the work was done at the University Farm at Davis, in the Sacramento Valley about thirteen miles west of Sacramento. The orchard was about six years old when the experiments were started and consisted of a collection of nine varieties of Japanese and fourteen varieties of European plums. All trees were in a healthy, vigorous condition and had been pruned annually by thinning out branches where too thick and by cutting off about two-thirds of the previous season's growth. In the Santa Clara Valley, where experiments were started in 1915, the trees used were twelve years old or older and had been in bearing for a number of years. In most cases these trees appeared less vigorous than those at the University Farm.

How the Work was Done.—With each variety the chief emphasis was placed upon the question as to whether or not it was self-fertile, in the sense of its being able to set and mature fruit when self-pollinated, regardless of whether a viable seed was produced or not. The first season (1914) blossoms of the varieties being tested were enclosed in paper bags (fig. 1) while still in the bud, after the method used by Waugh, and allowed to open and pollinate themselves while thus protected from insect visits. During the following year and all succeeding seasons, however, all blossoms thus enclosed were actually pollinated with pollen from the same variety. In this way lack of set would more fully indicate self-sterility and all doubts as to whether the stigma actually received pollen would be eliminated.

Crosses were made on each variety, using a number of other varieties of the same species that blossomed at approximately the same time. Varieties used in crossing were, as far as possible, commercial sorts adapted to the same general conditions as the female parent. No inter-species crosses were made.

With both the self-pollinations and the crosses the blossoms were emasculated by inserting the nails of the thumb and second finger through the calyx tube slightly below the point where the petals are attached, and then by a deft jerk removing petals and stamens with one movement. The ovary and style were seldom if ever injured.



Fig. 1.—Robe de Sergeant prune tree, showing blooming habit. Note paper bags used for covering flower clusters in the pollination experiments. University Farm Orchard, Davis.

Furthermore, any slight degree of mutilation to the flower was the same for the self-pollinations and the crosses.

Several thousand blossoms on different branches among the several trees were counted each year and left open to natural pollination by insects. Fruits resulting from these blossoms were counted three times during the season. The number of fruits secured by this natural pollination served as a check on the main experiments and are referred to hereafter as the "normal set." This count also constituted a record of the varying set from year to year so it would be possible to find what percentage of set constituted a satisfactory commercial crop.

The bags were removed from the self-pollinated and crossed fruits about three weeks after pollination, and the number of fruits set were counted at this time. They were counted a second time early in May and again before picking in order to observe their behavior throughout the season.

Except during the year 1914, no pollen was used until samples had been subjected to artificial germination tests.²

The early varieties, particularly the Japanese sorts, did not produce a plentiful supply of pollen and it was often difficult to secure viable pollen in time for use when the pistils were receptive. Pistils, if left for more than six days after emasculation, before pollen was supplied, usually gave a poor set of fruit. Furthermore, the varieties of plums used, did not yield better pollen when twigs were brought into the greenhouse and forced into bloom. This method, used by Lewis and Vincent with apples, did not work out successfully with plums.

EXPERIMENTAL RESULTS

Seasons of 1914-17 Inclusive, University Farm and Santa Clara Valley.—During the season of 1914 five varieties of Japanese plums and four varieties of European plums were experimented upon. The Japanese varieties were the Combination, Satsuma, Kelsey, Wickson, and Burbank. Two of the European type were Clyman and Tragedy, and the other two, French and Robe de Sergeant prunes. Between 1000 and 1500 blossoms were counted upon each variety to determine the normal set. From 900 to 1300 blossoms of each were self-pollinated and from 150 to 600 blossoms of each were crossed with the leading varieties in blossom at the same time. The work of emasculating and

² These tests are not included in this bulletin for lack of space, but are on file in the office of the Division of Pomology, where they may be consulted by those interested. The details of testing pollen, and also the collection and care of the pollen, as well as its transference to the flowers in the orchard, will be fully described in a following paper.

pollinating was done between February 25 and March 30. Records show the season to have been normal during the blossoming period.

In 1915 the work was carried on in a way similar to that done in 1914, except that all self-pollinations were actually made by hand to make sure each stigma received its supply of pollen. This method was used in all subsequent seasons. Climax and Sugar were included in the list of varieties in the experiment. The work, furthermore, was broadened to include investigations on the French, Sugar, and Imperial prunes in the Santa Clara Valley, the foremost prune producing section in California. Opportunity was given at the latter place for experimenting with mature trees of the type (fig. 2) generally conceded to be gradually falling off in production. Emasculations and pollinations at Davis were continued from March 3 to March 22. The weather during the early part of the season was moderately cool but later became unseasonably warm. This condition was especially noticeable in the Santa Clara Valley where the mean temperature for the month was 2.9° F. above normal. No precipitation was recorded. Considerable complaint was heard at the latter place because of the failure of the prunes to set a full crop and the cause was popularly attributed to the unusually warm weather at blossoming time. Results obtained at Davis generally substantiated those of the previous year. In the Santa Clara Valley the French and Sugar prunes showed a tendency toward self-fertility, while the Imperial pointed to self-sterility.

In 1916 the chief aim was to reduce experimental error as much as possible by increasing the number of blossoms used. The seasonal climatic conditions were approximately normal in both districts. At Davis the work was done between February 24 and March 18, while in the Santa Clara Valley the season was practically the same as that for the previous year. A strong north wind at Davis on one occasion blew a number of bags from the trees, injuring a number of blossoms under experiment. The results obtained at Davis were practically the same as for the previous seasons. In the Santa Clara Valley using large numbers of blossoms, it was decisively demonstrated that the three varieties of prunes grown there are well able to effectively cross-pollinate one another. Especially satisfactory results were obtained on the Sorosis ranch by crossing the French prune with the Imperial (fig. 3).

Two additional Japanese plums, Sultan and Abundance, and three additional European plums, Grand Duke, Pond, and Yellow Egg, were used in 1917. The weather during the early part of the season at Davis was unusually cold and the blossoms opened slowly, but

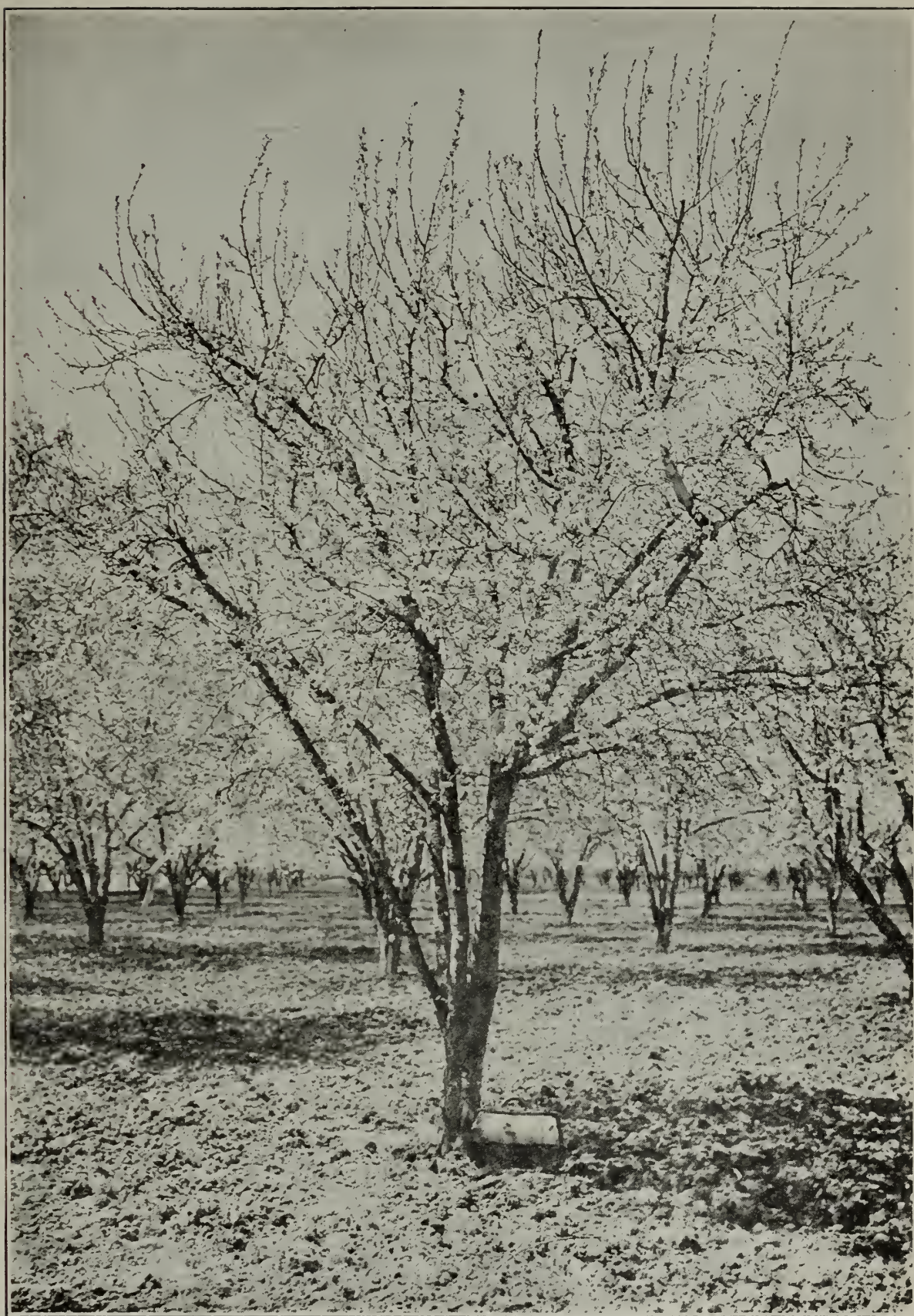


Fig. 2.—Old trees of French prune in the Santa Clara Valley. This variety blooms very profusely—much more so than the Sugar prune.

later, climatic conditions ameliorated and a succession of bright days gave ample opportunity for insect pollination. The later blooming varieties, consistent with previous seasons' results, set heavier than the early ones which open when the weather is still cold. In the Santa Clara Valley the season was one which brought the blossoms along slowly. A slight frost occurred nearly every night in the early part of the season, but no damage to the blossoms resulted. The work in the latter section was done between March 17 and March 24. The results coincided with those obtained in previous years, and considerable weight must be given to the results in the Santa Clara Valley



Fig. 3.—The two small branches of fruits shown are French $\times$ Imperial. These are typical of the results secured from crossing the French and Imperial in 1916.

as they were obtained from using 3000 to 5000 blossoms for each cross, all of which were hand pollinated. Results from both sections are fully discussed later in this paper.

Season of 1918: University Farm, Santa Clara Valley, and Vaca Valley.—The spring of 1918 was markedly unfavorable for pollination work on account of frosts, rain and high winds. At Davis rain fell on March 10, 11, and 12 and again during the week beginning March 16. A high wind on March 18 blew many bags from the trees, injuring many blossoms enclosed for experimental purposes. Finally, two killing frosts on the nights of April 4 and 5 followed two days of

high north winds. It was noticed on April 5 that many of the pistils of the French prune were killed and it is probable that blossoms on other varieties hand-pollinated a few days earlier were similarly injured. In addition to the foregoing difficulties there was a light bloom on many varieties, probably due to the dry autumn and winter preceding. It was therefore impossible to experiment upon Burbank, Satsuma, Kelsey, Abundance, Clyman, Yellow Egg, Pond, and Sugar.

As a result of this scarcity of blossoms at the University Farm, arrangements were made to continue the work with Japanese varieties on the farm of Mr. Millard Sharpe of Vacaville. Several new varieties—the Beauty, Formosa, Gaviota and Santa Rosa, were thus added to the experimental list. However, frost on the nights of April 4 and 5 caused considerable damage to fruit buds at Vacaville, the same as it did at Davis. As a consequence the only positive results obtained were with the Wickson, all other crosses and self-pollinations with the Japanese sorts being lost. The Wickson gave the following percentages of set with the various crosses: Satsuma, 6.6 per cent; Kelsey, 2.8 per cent; Beauty, 4.6 per cent; Formosa, 6.4 per cent; and Santa Rosa, 9.9 per cent. These results indicate that Wickson can be successfully cross-pollinated by Beauty, Formosa and Santa Rosa in addition to the varieties previously noted.

In general, the results at Davis with the few varieties which were uninjured by the frost were the same as for the preceding four seasons. Bloom on all varieties was scanty, and therefore in spite of a high percentage of set in some cases, the resulting yields did not constitute a heavy crop. In the Santa Clara Valley identical results with those of the three preceding years' work were obtained. The normal set of the French and Imperial prunes in the Sorosis orchard, however, showed a decidedly lower percentage than in 1917. This decrease was probably due to the exceptionally heavy crop produced by this orchard in 1917.³

PRESENTATION OF DATA

The essential data obtained during the five years are herewith presented in table 1. With the idea in view of presenting to the grower in an easily understandable form the essential results obtained from the work on the pollination of plums and prunes, only the total number of blossoms used, the average per cent of bloom that set fruit, the number of years averaged and the average yield per tree are given. Likewise a full discussion is given summarizing the results as a whole rather than taking up each year's results separately.

³ For full account see Calif. Agr. Exp. Sta., Bull. 291, *The Common Honey Bee as an Agent in Prune Pollination*.

TABLE 1

SUMMARY OF THE NORMAL SET AND SELF- AND CROSS-POLLINATION OF PLUMS AND PRUNES FOR THE YEARS 1914-1918

Variety and Treatment	Location of Orchard	Total No. of blossoms used	Av. per cent. of bloom that set fruit	No. of years averaged	Av. yield per tree for 1915, 1916 & 17	Notes
Combination						
Normal Set.....	Davis	5926	3.5	4	42	1914-17
×Self.....		2450	0	4		1914-17
×Kelsey.....		58	0	1		1914
×Satsuma.....		1788	1.6	4		1914-17
×Wickson.....		1213	0.75	2		1916-17
Kelsey						
Normal Set.....	Davis	4744	9.0	3	38.1	1915-17 frost 1918
×Self.....		1240	0	4		1914-18 frost 1918
×Combination....		54	0	1		1914
×Satsuma.....		589	1.5	2		1914 and 1917
×Burbank.....		465	0.55	2		1916-17 frost 1918
×Wickson.....		772	2.6	3		1915-17 frost 1918
Satsuma						
Normal Set.....	Davis	5094	3.9	3	34.8	1914, 15, 17 frost 1918
×Self.....		2414	0	3		1914, 15, 17 frost 1918
×Combination....		423	1.4	2		1914, 15
×Kelsey.....		173	0	2		1914 and 17
×Burbank.....		335	0.9	1		1917
×Wickson.....		484	6.4	1		1917 frost 1918
Burbank						
Normal Set.....	Davis	6123	25.6	4	85	1914-17 frost 1918
×Self.....		2957	0	4		1914-17 frost 1918
×Kelsey.....		833	1.2	2		1915, 16 frost 1918
×Satsuma.....		905	17.5	2		1914, 17 frost 1918
×Wickson.....		1470	15.0	4		1914, 17 frost 1918
×Climax.....		685	15.1	2		1914, 17 frost 1918
×Sultan.....		169	18.0	1		1916, 17 frost 1918
Wickson						
Normal Set.....	Davis	7301	4.8	4	106	1914-17 frost 1918
×Self.....		3582	0	4		1914-17 frost 1918
×Kelsey.....		921	1.8	3		1914-16 frost 1918
×Satsuma.....		1663	6.1	4		1914-17 frost 1918
×Burbank.....		1412	3.6	3		1914, 16, 17, frost 1918
×Climax.....		794	2.6	2		1916, 17
×Sultan.....		34	0	1		1917
×Abundance.....		230	1.3	1		1917
Climax						
Normal Set.....	Davis	6938	3.5	3	99	1915-17, frost 1918
×Self.....		1247	2.8	3		1915-17, frost 1918
×Kelsey.....		510	0.3	3		1915-17, frost 1918
×Burbank.....		1071	4.6	3		1915-17, frost 1918
×Wickson.....		1215	2.5	3		1915-17, frost 1918
×Abundance.....		441	4.6	1		1917, frost 1918

TABLE 1—(Continued)

Variety and Treatment	Location of Orchard	Total No. of blossoms used	Av. per cent. of bloom that set fruit	No. of years averaged	Av. yield per tree for 1915, 1916 & 17	Notes
Sultan						
Normal Set.....	Davis	2693	4.0	1	48 ¹	1917, frost 1918
×Self.....		300	0	1		1917, frost 1918
×Kelsey.....		140	1.9	1		1917, frost 1918
×Burbank.....		283	9.1	1		1917, frost 1918
×Wickson.....		394	12.2	1		1917, frost 1918
Abundance						
Normal Set.....	Davis	2338	24.1	1	126 ¹	1917, frost 1918
×Self.....		635	0.1	1		1917, frost 1918
×Burbank.....		383	5.4	1		1917, frost 1918
×Wickson.....		427	15.4	1		1917, frost 1918
×Climax.....		353	9.9	1		1917, frost 1918
Clyman						
Normal Set.....	Davis	6005	25.9	4	36.7	1914–17
×Self.....		1126	0	2		1916, 17
×Tragedy.....		509	18.1	3		1914, 16, 17
×Yellow Egg.....		159	1.2	1		long interval 1917
×Pond.....		37	13.5	1		1917
×Grand Duke....		76	10.3	1		1917
Tragedy						
Normal Set.....	Davis	6270	20.9	5	118	1914–18
×Self.....		3679	0.02	5		1914–18
×Clyman.....		2507	14.7	4		1914–17
×Yellow Egg.....		517	8.75	2		1916 long interval 1917
×Pond.....		513	0.75	2		
×Grand Duke....		1235	4.4	3		1916, 17, frost 1918
×Robe de Sergeant.....		100	27.7	1		1914
×Sugar.....		34	2.9	1		1915
Yellow Egg						
Normal Set.....	Davis	880	58.7	1	38 ¹	1917
×Self.....		301	9.3	1		1917
×Tragedy.....		239	8.7	1		1917
×Pond.....		283	18.3	1		1917
×Grand Duke....		299	5.7	1		1917
Pond						
Normal Set.....	Davis	1205	41.7	1	60 ¹	1917
×Self.....		306	4.2	1		1917
×Yellow Egg.....		268	21.3	1		1917
×Grand Duke....		268	7.5	1		1917
Grand Duke						
Normal Set.....	Davis	1965	31.5	2	135 ¹	1917, 18, frost 1918
×Self.....		684	0.01	2		1917, 18, frost 1918
×Clyman.....		320	6.9	1		1917
×Tragedy.....		696	0	2		1917, 18, frost 1918
×Yellow Egg.....		309	0.3	1		1917
×Pond.....		395	0.2	1		1917

¹One year.

TABLE 1—(Continued)

Variety and Treatment	Location of Orchard	Total No. of blossoms used	Av. per cent. of bloom that set fruit	No. of years averaged	Av. yield per tree for 1915, 1916 & 17	Notes
French						
Normal Set.....	Davis	8109	33.0	5	81.4	1914-18, frost 1918
×Self.....		2743	3.02	5		1914-18, frost 1918
×Sugar.....		1341	10.6	4		1914-17
×Robe de Sergeant.....		1756	6.6	4		1914-17
Sugar						
Normal Set.....	Davis	1919	41.6	2	88.7	1915, 17
×Self.....		417	8.1	2		1915, 17
×French.....		332	2.7	1		1917
×Robe de Sergeant.....		121	0.8	1		1917
Robe de Sergeant						
Normal Set.....	Davis	6204	19.7	5	91.4	1914-18, frost injury '18
×Self.....		2754	0.16	5		1914-18, frost injury '18
×French.....		1780	10.5	5		1914-18, frost injury '18
×Sugar.....		1272	13.2	4		1914-17
×Tragedy.....		579	20.4	2		1914, 17
×Pond.....		153	45.1	1		1914
×Imperial Gage..		215	20.0	1		1914
French						
Normal Set.....	Cupertino	20939	4.0	4	 ²	1915-18
×Normal Set.....		14845	4.4	4		1915-18
×Self.....		2948	9.6	4		1915-18
×Imperial.....		2156	23.5	4		1915-18
×Sugar.....		2530	21.1	4		1915-18
French ³						
Normal Set.....	Saratoga	23661	7.6	4	 ²	1915-18
Normal Set ⁴		18774	6.5	4		1915-18
×Self.....		5052	5.05	4		1915-18
×Imperial.....		6195	10.9	4		1915-18
×Sugar.....		6022	22.8	3		1916-18
Imperial						
Normal Set.....	Cupertino	6529	3.5	3	 ²	1915-17
×Self.....		1083	0.3	3		1915-17
×French.....		635	1.3	3		1915-17
×Sugar.....		819	6.0	3		1915-17
Imperial						
Normal Set.....	Saratoga	7315	7.25	4	 ²	1915-18
×Self.....		4010	1.5	4		1915-18
×French.....		5039	8.7	4		1915-18
×Sugar.....		4783	5.0	3		1916-18
Sugar						
Normal Set.....	Cupertino	7299	11.7	4	 ²	1915-18
×Self.....		1077	8.4	4		1915-18
×French.....		1054	13.9	4		1915-18
×Imperial.....		993	11.1	4		1915-18

²No weights taken.³Next to Imperials.⁴Five rows from Imperials.

DISCUSSION OF RESULTS

Japanese Varieties.—By a study of table 1 it will be noticed that the average set of fruit for the Japanese varieties under ordinary orchard conditions prevailing at the University Farm, was approximately 4 per cent. Only in a few cases is there a noticeable deviation from this average. Kelsey on a three-year average set 9 per cent, and Abundance, in the one-year counts made on that variety, set 24.1 per cent. For four years the Burbank has maintained the remarkably high average of 25.6 per cent. Invariably this variety set fruit so thickly that a heavy thinning was necessary to bring the fruit up to marketable size. All varieties of Japanese plums were given the same kind of care and pruned in the same way, consequently the percentage of fruit set by each should be considered a varietal characteristic. The heavy set obtained with the Burbank often necessitates thinning. Other varieties, notably the Wickson and Climax, matured satisfactory commercial crops without the added expense of the heavy thinning which was necessary in the case of the Burbank.

The yield records for these trees which are available for the years 1915, 1916, and 1917, show some further interesting facts. The first three varieties, which as a rule are the first to blossom each spring, show a comparatively low yield record. Combination yielded at the average rate of 83, 24, and 20 pounds per tree for the three years, giving an average of 42 pounds per tree resulting from a set of 3.5 per cent. Kelsey gave a consistent average yield of 46, 38.4, and 30 pounds, or a total average of 38.1 pounds for three years from an average set of 9 per cent. No great difference in yield followed in 1917 as the result of the low percentage of set. Satsuma produced an average yield per tree of 40.4 and 60 pounds, or a total average of 50.2 for the years 1915 and 1917. These yields resulted from an average normal set of 3.9 per cent. The foregoing varieties blossom very early and the yields thus far can only be considered fair from a commercial point of view.

Burbank produced an average yield per tree of 74.5, 108, and 73 pounds, giving a total average of 85 pounds per tree, as a result of the continued high average set of 25.6 per cent. While this crop was entirely satisfactory, it must be compared with the next two given below to arrive at the value of the percentage of set as a determining factor in the amount of fruit produced. Wickson matured an average per tree of 84, 89, and 147 pounds, or a total average of 106 pounds per tree as a result of the comparatively low set of 4.8 per cent. Climax responded similarly to Wickson. It set an average of 82, 83.4,

and 132 pounds per tree or a total average of 99.1 pounds per tree for three years, resulting from an average set of 3.5 per cent. Sultan showed during one year some of the characteristics of Climax and Wickson by maturing a set of 4 per cent or 48 pounds of fruit per tree. Abundance on the other hand matured a set of 24.1 per cent or 126 pounds per tree.

The most noticeable result of the past four season's work, with the Japanese varieties, excluding the results with most varieties during 1918 because of frost injury, is the distinctness with which they fall into one of two classes—those which are self-sterile and those which are self-fertile. Only one variety, the Climax, out of the eight varieties experimented with is self-fertile. All the others never, or practically never, set fruit when self-pollinated.

In the field method of experimentation with which these experiments were carried out, no morphological defects in any of the flowers were detected. Some of the blossoms of the Wickson variety produced very short pistils that measured approximately one-fourth the length of a normal pistil. These, however, were never used. The factor of self-sterility as far as could be shown was simply due to the inability of the several varieties to set fruit with their own pollen. In making the counts after blooming time there never was any doubt as to what varieties were self-sterile. The self-pollinated pistils turned yellow and dropped soon after the pollen was applied. Often blossoms open to insect pollination, and which dropped off later, still retained their floral parts and were firmly attached to the limb, when the self-pollinated ones had withered and fallen. Sometimes a few fruits persisted until the second count, but all usually fell before the fruit ripened.

As a result of four years' experimentation in crossing the Japanese plums with one another, one fact stands out with remarkable consistency, which is that whenever crosses were made using the pollen of Combination and Kelsey the set of fruit was low. The cause cannot be stated with certainty but in the opinion of the writer it is probably due to inability to secure strong vigorous pollen from these varieties. Their natural production is usually scanty, and being formed while the weather is still cold it is often necessary to wait until late in the season to secure a supply. Even then, the germination tests rank among the lowest of any of the varieties used. The low results from using the pollen of these varieties even on some of the later more vigorous ones, agree with the low average yield of these varieties, inasmuch as they must, for the most part, be inter-pollinated through the agency of insects, or from the very early blossoms of the later

blooming varieties. Combination and Kelsey must be considered as inferior pollenizers not only among themselves but for some of the other later varieties. Furthermore, it has not been possible to obtain a satisfactory set by crossing artificially, when either the Combination or Kelsey were used as the female parent.

The Satsuma has been successful as a pollenizer for several of the early and mid-season blooming kinds. This was especially true when either the Burbank or Wickson were used as the female parent. No variety has proved particularly valuable as a cross-pollenizer for the Satsuma, though pollinated by the Wickson, one season it produced a set of 6.4 per cent. Since the Satsuma is known as a shy bearer in many sections of the state it is unfortunate that a satisfactory pollenizer of it was not found.

Results with Burbank indicate that while absolutely self-sterile it is readily pollinated by any one of the several varieties used, and is also an efficient pollenizer for the other varieties which blossom at the same time. The only poor results were obtained when Kelsey was used as the male parent. The reciprocal of this cross, viz., Kelsey $\times$ Burbank, also gave low results both years it was tried. Crossed with Satsuma, Wickson, Climax, or Sultan, Burbank gave as satisfactory results as could have been desired. The reciprocals of these crosses were also satisfactory. Burbank is undoubtedly one of the most efficient pollenizers of its season, and a valuable variety for this reason.

The Wickson was also found to be a reliable cropper and an excellent pollenizer. When Wickson was used as the female parent all pollenizers gave satisfactory results except Kelsey, Sultan, and Abundance. Kelsey has already been mentioned as an unreliable pollenizer. The Sultan and Abundance crosses were only made in 1917 and as the interval of time between emasculation and pollination was eleven and twelve days, respectively, these two varieties cannot be eliminated as pollenizers for the Wickson without further trial. Wickson has proved its worth as a pollenizer for Satsuma, Burbank, Climax, Sultan, and Abundance by the high average set these crosses produced throughout a series of trials. With Burbank it ranks as one of the best pollenizers.

Climax in addition to being self-fertile was found to be easily pollenized with Burbank, Wickson, and Abundance. With Kelsey as the male parent, no better results were obtained than when Kelsey was used with other varieties. Climax pollenized Burbank, Wickson, and Abundance satisfactorily. Because of its tendency toward self-fertility, and because it is a good pollenizer, Climax is a valuable variety. Furthermore, it blossoms rather late in the season, thus tending to escape late spring frosts.

Although tried out but one year Sultan and Abundance gave evidence of being useful as pollenizers. They also gave high sets when crossed with Burbank, Wickson, and Climax. Because of their late blossoming they should be valuable to interplant with Burbank, Wickson, or Climax.

European Shipping Plums.—The tendency has been with the young trees of Clyman and Tragedy varieties on the University Farm to increase year by year the percentage of fruit set. With each increase in percentage of fruit set, has come an increase in yield. Thus the trend of both the percentage of set and the yield has been upward. Records also show that the Yellow Egg, Pond, and Grand Duke varieties have steadily increased in yield year by year, but no records were kept of the percentage of blossoms which set fruit until 1917, so no comparison can be made. These European varieties set a higher percentage of blossoms than do the Japanese varieties, but have not as yet produced a markedly larger crop.

Clyman produced an average of 22.5, 27.7, and 60 pounds per tree, or an average for the three years of 36.7 pounds from an average set of 25.9 per cent. This average can only be considered a fair commercial crop. Coupled with the fact that a high percentage of set produces only a small commercial crop, it would seem as if this variety did not produce enough blossoms to make it a success; it would in fact probably soon be discarded, if it were not for its value as a pollenizer of the Tragedy. It has a reputation for light bearing and the fruit is not above mediocre in quality for shipping.

The Tragedy, on the other hand, has matured an average per tree of 55, 85.6, and 215 pounds, or an average set of 23.7 per cent for four years. Thus with this variety a high set has given a good commercial crop. An average production of 118 pounds per tree from the Tragedy, as compared with 36 pounds per tree from the Clyman, with the percentage of set practically the same, would seem to indicate that the Tragedy was much more prolific in the production of blossoms. Furthermore, it produces a great many fruit spurs, and the fruit itself is of such quality that it is a general favorite. Yellow Egg, Pond, and Grand Duke all show evidence of maturing a comparatively high percentage of set.

The self-sterility of the two varieties experimented upon for four years was well established. There is no question, either from growers or from experimental data at hand, but that Clyman and Tragedy must be cross-pollinated to produce satisfactory crops. Grand Duke in one year's experiments also seems self-sterile. Yellow Egg and Pond both set a small percentage of fruit when self-pollinated, show-

ing that not as large a proportion of European plums are self-sterile as was the case with the Japanese varieties.

Decisive results have shown the best pollenizers for at least some of the five varieties thus far experimented upon. Clyman was satisfactorily pollinated with Tragedy, Pond, and Grand Duke. The average set of Clyman crossed with Tragedy for three years was 17.1 per cent. While Yellow Egg did not give a high result when used with Clyman, this fact cannot be construed to mean it will not pollinize the latter, as an eleven-day interval elapsed between emasculation and pollination. In turn, Clyman for four years has been a highly efficient pollenizer for Tragedy, as shown by the average set of 14.7. Clyman also pollinated Grand Duke effectively. Despite its serious drawbacks, there is no question as to the value of Clyman as a pollinator of the Tragedy. It might even be good commercial practice to interplant Tragedies with a few Clymans solely for the benefit of the former.

For the valuable and important variety, Tragedy, a number of the European varieties of plums seem to be efficient pollenizers. Chief among these is the Clyman. Next in importance, and blossoming with it at Davis, is Grand Duke. In three seasons this cross gave an average set of 4.4 per cent. Robe de Sergeant in 1914 crossed on Tragedy gave a set of 27.7 per cent which, while high, probably is of no commercial importance because of the fact that these two varieties are not adapted to being grown in the same districts. As with some other varieties, the crosses of Yellow Egg and Pond on Tragedy, the only year they were tried, were made so late that the pistils were not in good physical condition. As a pollenizer Tragedy does well both on Clyman and Grand Duke, so that it might be interplanted with either of these varieties to advantage.

The Grand Duke, Yellow Egg, and Pond inter-pollinated successfully in 1917 when the pollen was applied before the pistils began to wither. In general they have proved to be excellent pollenizers not only for themselves, but for the Clyman and Tragedy also. As these latter varieties have been used for practically only one year their value cannot be considered as authoritative as that of varieties tried out for four seasons. All of the European shipping plums which have come under observation have proved to be abundant pollen producers. Furthermore, the pollen is easily germinated and generally shows a high percentage of viability.

Prunes.—The three varieties of prunes, French, Sugar, and Robe de Sergeant, experimented upon at the University Farm have set comparatively high percentages of fruit and matured fairly satis-

factory crops considering the age of the trees. The French and Robe de Sergeant yielded consistently each year, but the Sugars failed to blossom in 1916. As this failure followed a heavy crop it was thought that the drain upon the tree had been so great that it was unable to mature fruit buds for the following season. This variety again in 1918 behaved in the same manner, failing to produce any blossoms. This seeming tendency towards alternate bearing is an uncommon occurrence with this variety. The general reports concerning it are that it bears heavily and regularly. However, from four years' data



Fig. 4.—The characteristic shape of the French prune was not influenced by being pollinated by other varieties. In this case the crosses were made with Sugar and Imperial.

at Davis, it would seem that if young trees just coming into profitable bearing are allowed to overbear one year, only a light crop is produced the following season. One of the most serious criticisms of the Sugar prune is that it tends to overbear.

The French and Robe de Sergeant at Davis, on the basis of regularity in bearing, have proved to be more valuable than the Sugar. The former variety during the three years of 1915, 1916, and 1917 produced an average crop of 57.5, 41.7, and 145 pounds, respectively, or an average of 81.4 pounds per year for the three years. This crop resulted from an average set of 28.7 per cent. The Robe de Sergeant practically equaled the record of the French. In three years the

average crop per tree was 95.1, 79.6, and 100.6 pounds, or a total average per tree of 91.4 pounds from an average set of 17.4 per cent. Roughly speaking, the above yields approximate three tons of green fruit per acre, which is a fairly satisfactory commercial yield considering the age of the trees (eight years in 1915). In the case of the Sugar prune the average yield is only available for two years, as no crop at all was produced in 1916. These yields were 30.1 and 147.3 pounds per tree, or an average of 88.7 pounds per tree for the two years, resulting from the high average percentage of set of 41.6 per cent. If this yield is calculated on the basis of three years, as might properly be done, the average yield for the variety is thus reduced to but 59.1 pounds per tree.

Two varieties of these prunes, the French and Sugar, are self-fertile, while the third, Robe de Sergeant, is self-sterile. Four years' results with self-pollinating the French prunes have shown great fluctuation in the percentage of fruit obtained. Some years this percentage was high and in others it was low, but the average for four years shows that this variety must be accepted as self-fertile. Upon what factors this self-fertility depends is not known but it seems to be largely a matter of applying the pollen at exactly the right time. Climatic conditions following the application of pollen may also exert some influence on the resultant set. This conclusion as to the self-fertility of the French prune, which is emphasized by the Santa Clara experiments, is of utmost importance to the prune growers of California. It shows why vast acreages of this variety have been able to produce crops year after year without the necessity of growing fillers as pollenizers. The next problem is to find what environmental conditions favor the highest percentage of set when the blossoms are pollinated with their own pollen, as must necessarily be the case in most of our prune-growing sections.

The Sugar prune which is supposedly a seedling of the French showed an average set of 8.1 per cent from self-pollinated flowers. This evidence was corroborated by data obtained in the Santa Clara Valley (four-year average, 8.4 per cent) and shows there is no need of interplanting other varieties with the Sugar for purposes of cross-pollination. The Robe de Sergeant has emphatically and consistently proved to be self-sterile and in urgent need of cross-pollination to secure crops. These data support the widespread contention among growers that unless it is properly interplanted with other varieties, the Robe de Sergeant is a shy bearer.

In spite of their reputed relationship no trouble was experienced during the four years in obtaining satisfactory sets when French was

crossed with Sugar or *vice versa*. The French prune was found to be readily cross-pollinated by either the Sugar or Robe de Sergeant. Although the average result of these hand-made crosses was not as high as the set under open orchard conditions, they were higher than the average set resulting from the self-pollinations. Thus it was shown that, even though self-fertile, the French prune might still be benefited by pollen other than its own. The French prune has the additional good quality of being a heavy pollen producer and an excellent pollinizer for the other varieties of prunes. The French

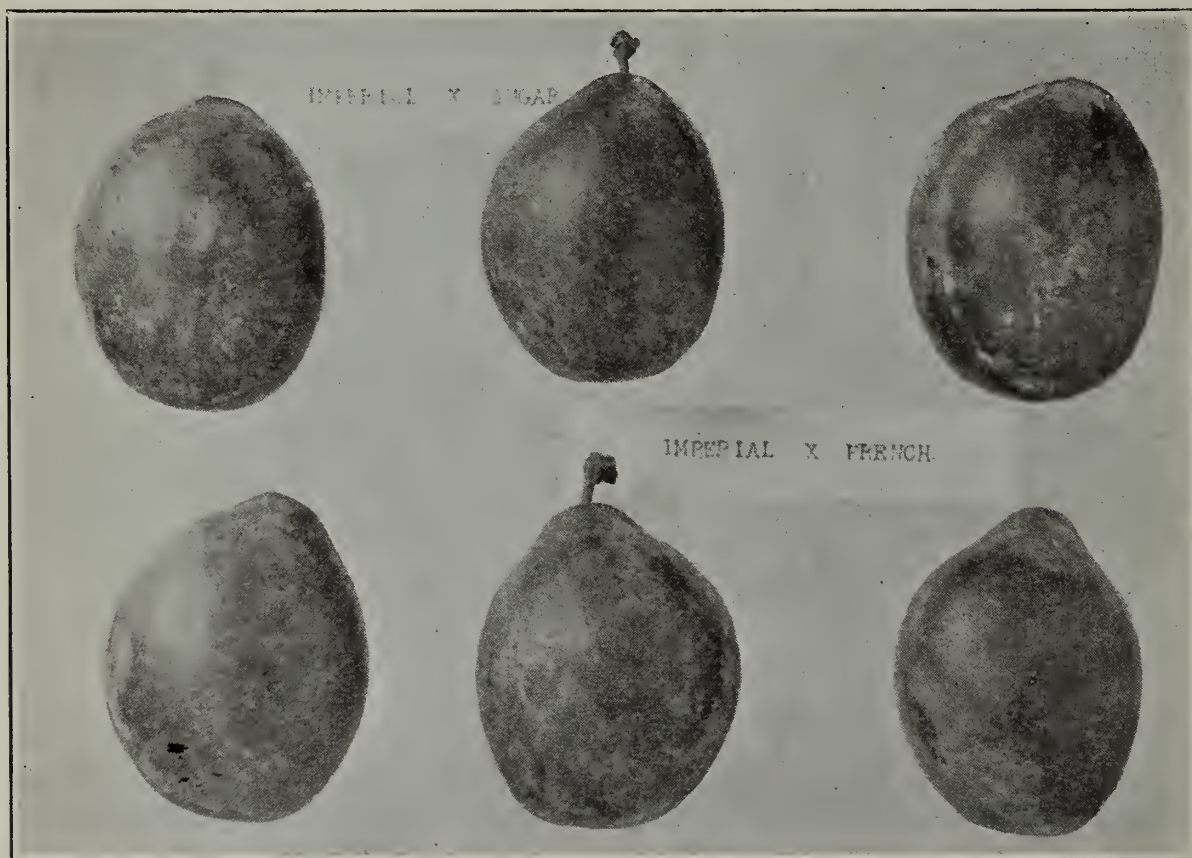


Fig. 5.—Shows results of pollinating the Imperial with pollen from the Sugar and French varieties. The typical shape of the Imperial is retained by the fruits.

as a pollinizer for the Robe de Sergeant gave an average of 10.5 per cent set for the five-year period. The one year's results as a pollinizer for the Sugar cannot be considered infallible as results in the Santa Clara Valley have proved the French an efficient pollinizer for the Sugar. The probable causes of the low set for this particular cross are discussed elsewhere (p. 20).

No eminently noticeable results were obtained at Davis when Sugar was used as the female parent. Due to various causes the crosses shown in the table were only tried once. As a pollinizer for both the French and Robe de Sergeant, the Sugar has no equal. It produces an abundance of pollen, blossoms at practically the same

time, and has proved effective in four years' trials. The high percentage (10.6 per cent) when used on French, and the still higher percentage (13.2 per cent) when used on Robe de Sergeant, amply attest its value.

While Robe de Sergeant was proved to be self-sterile, it was also shown to be readily capable of fertilization by any other European plum blossoming at the same time. French and Sugar as pollenizers for four years gave the best average results, but Tragedy, Pond, and Imperial Gage, tried for a lesser number of seasons also show possibilities as pollenizers for this variety. It is perhaps important to note that the prunes commonly grown with the Robe de Sergeant are so efficient as pollenizers that the other varieties mentioned (Tragedy, Pond, and Imperial Gage), are rarely found planted with it. As a pollenizer it has proved effective on the French, but because of an improperly timed operation in the one year it was tried, it was not so successful on the Sugar. In view of the foregoing it would certainly seem advisable to interplant Robe de Sergeant prunes with either the French or Sugar varieties.

Review of the Results Obtained in the Santa Clara Valley.—The most interesting fact noticed in studying the set of the fruit under open orchard conditions in two Santa Clara Valley orchards was the small percentage of blossoms which matured fruit. Yet it is with these low percentages of set that the commercial crop of prunes of California is produced. In the Pettit orchard at Cupertino this set has been remarkably uniform and has yielded each year what the owner considers to be a fair crop. In the Sorosis orchard at Saratoga the set was fairly uniform for 1915 and 1916, but in 1917 the owner placed some 115 colonies of bees in the orchard during the blossoming season. Because of the bees the percentage of set increased greatly in 1917 and raised the average for the three-year period up to 8.3 per cent.⁴ Moreover, the yield emphasizes the effective work of the bees. In 1916 with the normal set averaging 3.2 per cent the yield on 180 acres was 344 tons of dried prunes. On the same acreage in 1917 with an average set of approximately 12.9 per cent the yield was 432, or an increase of nearly 100 tons of dried fruit. It is interesting to contrast the small percentage of normal set in the Santa Clara Valley with the high percentages of normal set on the younger trees at the University Farm.

One of the chief problems confronting the grower of the Imperial variety, is how to get it to yield more heavily. Its value for a fancy dried prune cannot be surpassed as far as quality and flavor are

⁴ For full account see Cal. Exp. Sta. Bull. 291.

concerned, but the tree except in a few localities, has persistently refused to bear profitably. In the Pettit orchard the normal set has held consistently between 3 and 4 per cent, averaging 3.5 per cent in the last three years. Crops resulting from these percentages of set were not especially heavy. In the Sorosis orchard the normal set for four years average 7.25 per cent. The resultant yield each year was considered good, and the orchard has a reputation for heavy yields as far as this variety is concerned. Although the actual percentages of normal set for the years 1916, 1917, and 1918 were low, due probably to the comparatively small number of trees used in making the count, nevertheless a somewhat larger crop was harvested in 1917 than the year before, due to the work of bees.

The Sugar prune trees in the Pettit orchard averaged under normal conditions a set of 11.7 per cent. Although this is a comparatively high percentage, the scarcity of blossoms made the resultant yields rather below what might be considered a good crop. The Sugar prune does not blossom so profusely as either the French or the Imperial. Again the normal set in the Santa Clara Valley was lower than on trees of the same variety at Davis. Because of the general scarcity of blossoms on the Sugar it is doubtful whether the average percentage of set obtained in the Pettit orchard is high enough to be commercially profitable.

There was but little doubt left at the end of three years as to the self-fertility of the French, Sugar, and Imperial prunes as grown in the Santa Clara Valley. Results in 1918 tend strongly to confirm these results. The French in both orchards has consistently proved to be self-fertile. This fact is so plainly evident that further discussion is unnecessary.

Except for one year the Imperial has proved to be self-sterile, or practically so. In 1917, in the Sorosis orchard, a set of 5.3 per cent was obtained. In the Pettit orchard with the same variety in 1916 about 1 per cent set resulted. At Sorosis it was absolutely self-sterile in 1918.

The set of 5.3 per cent in 1917, together with the fact that another Imperial tree when enclosed in a tent with bees matured a crop of 3 per cent, shows that at times this variety is probably capable of self-fertilization. One year's satisfactory results, out of four, however, is far too small a proportion to warrant depending entirely upon self-pollination to set a crop. Neither does practical experience warrant it. For the purpose of the general fruit grower it must be considered self-sterile and careful steps taken to bring about heavier production by interplanting with a good pollinator.

Investigations as to the probable cause of self-sterility of this variety have not as yet gone beyond the stage of observation. A number of peculiarities have been noticed, each of which may have some bearing on the problem. The Imperial is perhaps the most prolific bloomer of all the varieties of European plums commonly found in California. The blossoms are tightly packed in great profusion on rather short, rigid spurs. Often a comparatively large proportion of these blooms appear weak; the petals are small and far apart, and the stamens and pistils are short. Quite often the flower does not open properly, but allows some of the outer floral parts to remain folded over the sexual organs. The stem is very short and the whole flower often drops easily even when touched lightly. The remainder of the flowers seem normal in every respect and are produced on a long stem. Another peculiarity was noticed about the Imperial pollen. It germinated slowly and made a very short growth, probably not more than one-fifth as long as the tubes put out by either the Sugar or French varieties. In many cases the tube was hardly more than a fairly distinct bulge on the side of the pollen grain. Germination counts for this variety were often made twelve or twenty-four hours later than with the other varieties to obtain tubes long enough to be readily distinguished.

The Sugar prunes were found to be able to set fruit with their own pollen. This evidence supports the data obtained at the University Farm. During the season of 1918, the yield obtained from self-pollinated flowers was the best of the four years, and practically the same as the yields obtained from either the Imperial or French crosses.

Careful work for three years failed to show any lack of affinity between any of the three varieties of prunes principally grown in the Santa Clara Valley. Occasionally a particular cross in one or the other of the orchards used, failed to mature a crop. This was particularly true the first season in the Sorosis orchard, because of the extremely warm weather. The same crosses in the Pettit orchard made a day or two earlier were eminently successful. Since the first year nearly all the cross-pollinations made have responded positively, except in 1917 when the Sugar and Imperial crossed with French failed to set. The Imperial $\times$ French cross, however, was successful at Sorosis, and the Sugar $\times$ French cross in 1918 was also successful. Chief value should be attached to the 1917 results, as they were obtained by using a very large number of each cross.

The French prune at both places showed a remarkably high average set when crossed with either Imperial or Sugar. As a pollenizer for the other two varieties, it did not average high during the

three years, but nevertheless served efficiently. The 1918 results tend to bring up this average. With the Imperial, the crosses made by hand did not average as high as the normal set, but from the excellent results obtained in individual years, this variety was shown to be easily pollinated by the other. As a pollenizer it averaged higher than the French. The Sugar proved capable of being pollinated by both Imperial and French and likewise served as an efficient pollenizer for them. On the strength of the foregoing facts there can be no doubt about the value of interplanting these varieties for cross-pollination. The Imperial, especially, needs this cross-pollination.

Careful observation showed that crossing the varieties produced no effect on the size of the fruit produced. This was true even when Imperial pollen was used on a small fruited variety like the French. Neither were there any noticeable effects on the shape of the fruits as a result of the cross-pollination (figs. 4 and 5).

CONCLUSIONS

1. The following varieties of Japanese plums were found to be self-sterile at the University Farm at Davis, California: Combination, Kelsey, Satsuma, Burbank, Wickson, Sultan, and Abundance.

2. Climax, another Japanese variety, is apparently self-fertile.

3. In general, the early blooming Japanese varieties such as Combination, Kelsey, and Satsuma, are scanty pollen producers and not effective pollenizers, while the later blossoming varieties such as Burbank, Wickson, Climax, Sultan, and Abundance produce pollen abundantly and are effective pollenizers.

4. Clyman, Tragedy, and probably Grand Duke, are self-sterile, while Yellow Egg and Pond from one year's data appear self-fertile. Pond, or Hungarian Prune, as it is known in California, has long been popularly regarded as self-sterile, so too much weight should not be given to the results obtained in one year.

5. All of the five European varieties tested seemed to be abundant pollen producers and to cross-pollinate one another effectively.

6. The French and Sugar prunes are self-fertile and therefore need not be interplanted with other varieties to secure satisfactory yields. It is probable, however, that their yield may be increased, especially in certain years, if interplanting is practiced.

7. Imperial and Robe de Sergeant prunes must be considered self-sterile for practical purposes.

8. Sugar, Imperial, and French prunes cross-pollinate one another effectively. Robe de Sergeant was found to cross-pollinate readily with Sugar and French, but was not tested with Imperial.

9. No evidence of inter-sterility among plums or prunes was found.

10. A comparison over a number of years between trees where there was an abundance of bees flying and trees where bees were scarce, emphasized the desirability of having bees in the orchard. Even self-fertile varieties were immensely benefited by the presence of bees as an agency for distributing the pollen.

11. Climatic factors are probably important in the setting of plums and prunes as evidenced by the fluctuating set obtained with certain crosses in succeeding years. Investigations, however, have not progressed far enough as yet to throw any light upon this phase of the problem.

12. The following is a list of self-fertile and self-sterile plums and prunes as found by the Division of Pomology of the University of California.

<i>Self-sterile</i>	<i>Self-fertile</i>	<i>Doubtful</i>
Combination	Climax	Pond
Kelsey	French	
Satsuma	Sugar	
Burbank		
Wickson		
Sultan		
Abundance		
Clyman		
Tragedy		
Yellow Egg		
Grand Duke		
Imperial		
Robe de Sergeant		

ACKNOWLEDGMENTS

The author was assisted at various times by R. R. Holeman, H. A. Houston, F. M. Croce, E. S. Yocco, and W. O. Dessauer, who as members of succeeding classes in pomology worked on special phases of the pollination problem for their theses. In the Santa Clara Valley the former Horticultural Commissioner, Mr. Earl Morris, as well as the present Commissioner, Mr. R. F. Cody, gave material assistance. The author takes this opportunity of expressing his appreciation and thanks for the aid rendered by these men. Thanks are also due to Mr. E. F. Pettit of Cupertino, Mr. Frank Abernathy, manager of the Sorosis Fruit Company, and Mr. Millard Sharpe of Vacaville, who placed their orchards at his disposal. The writer is indebted to Dr. W. L. Howard of the University Farm for his painstaking care in correcting and revising the manuscript, as well as for much helpful advice in the course of the investigations.

LITERATURE CITED

WAUGH, F. A.

The Pollination of Plums. 10th, 11th, 12th, and 13th reports of the Vermont Agric. Exp. Sta., 1896, 1897, 1898, 1899.

GARDNER, V. R.

Pollination of the Sweet Cherry. Oregon Agric. Exp. Sta. Bull. 116, 1913.

TUFTS, W. P.

Almond Pollination. Calif. Agric. Exp. Sta. Bull. 301, 1919.

LEWIS, C. I., and VINCENT, C. C.

Pollination of the Apple. Ore. Agric. Exp. Sta. Bull. 104, 1909.